CENTRE HOSPITALIER INTERCOMMUNAL
TOULON - LA SEYNE SUR MER

Benefits, risks, and outcomes for fully closed loop ventilation

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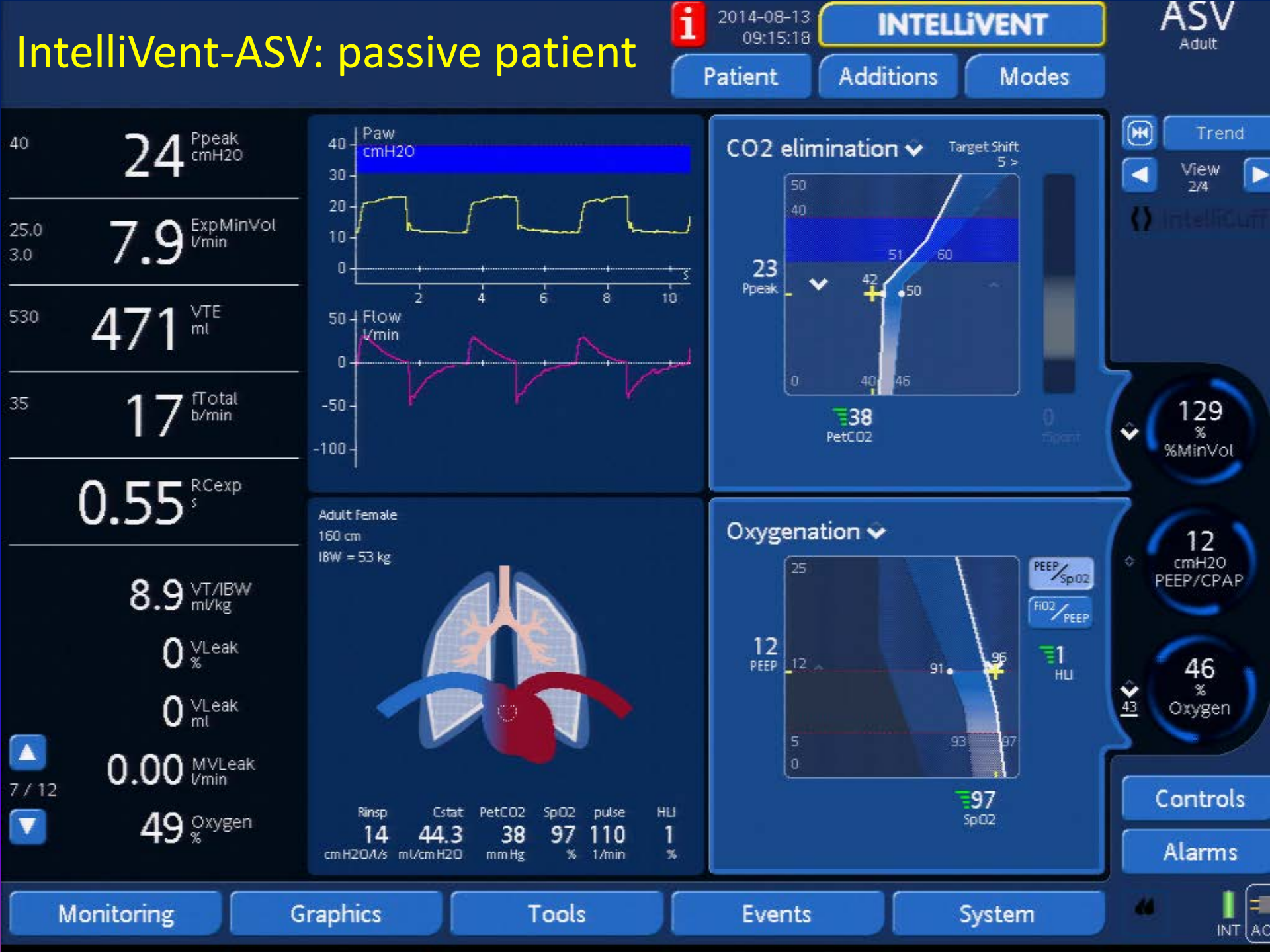
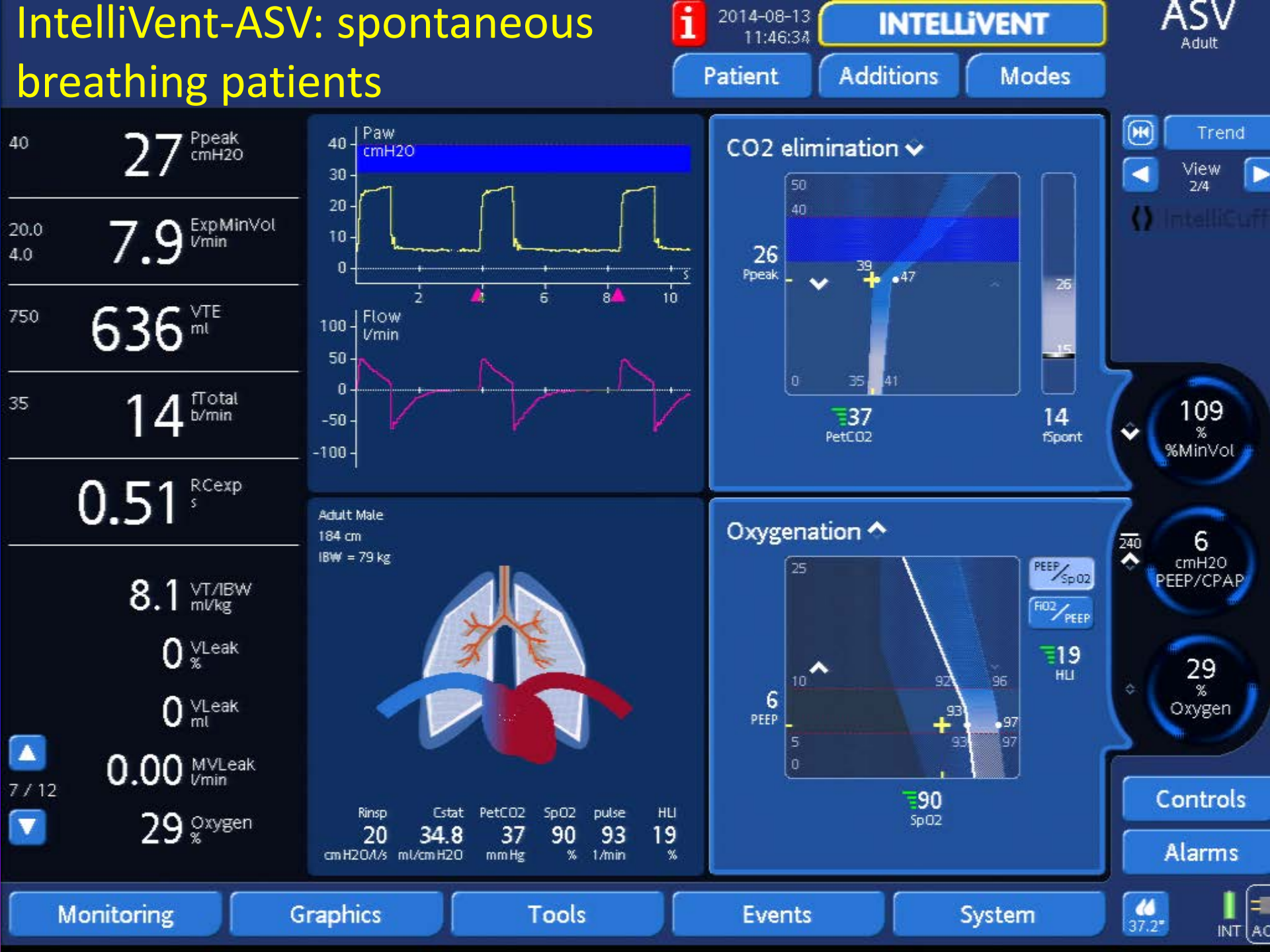
HAMILTON-S1

IntelliVent-ASV: passive patient



IntelliVent-ASV: spontaneous breathing patients



Benefits of IntelliVent-ASV
Safety and efficacy

- **Safety:**
  - Number of safety events
  - Number of switch to other modes
  - % time spent in non desirable ranges
- **Efficacy:**
  - % time spent in optimal ranges

Underlying condition	Resp muscles	"Desired" values
None	Passive	$92 \leq SpO_2 < 96\%$
ALI/ARDS	Passive	$88 \leq SpO_2 < 96\%$
None or ALI/ARDS	Active	$92 \leq SpO_2 < 96\%$
Brain injury	Passive or active	$95 \leq SpO_2 < 99\%$
Chronic hyperCO_2	Passive or active	$88 \leq SpO_2 < 94\%$
None	Passive	$30 \leq EtCO_2 < 41$ mmHg
ALI/ARDS	Passive	$30 \leq EtCO_2 < 45$ mmHg
None or ALI/ARDS	Active	$25 \leq EtCO_2 < 45$ mmHg
Brain injury	Passive or active	$30 \leq EtCO_2 < 33$ mmHg
Chronic hyperCO_2	Passive	$40 \leq EtCO_2 < 45$ mmHg
Chronic hyperCO_2	Active	$40 \leq EtCO_2 < 55$ mmHg
None	Passive	$6 \leq TV < 10$ mL/Kg PBW
ALI/ARDS	Passive	$5 \leq TV < 8$ mL/kg PBW
None or ALI/ARDS	Active	$6 \leq TV < 10$ mL/Kg PBW
Brain injury	Passive or active	$6 \leq TV < 10$ mL/Kg PBW
Chronic hvperCO_2	Passive or active	$7 \leq TV < 10$ mL/kg PBW
None	Passive	$6 \leq Pplat < 25$ cmH_2O
ALI/ARDS	Passive	$6 \leq Pplat < 30$ cmH_2O
None or ALI/ARDS	Active	$6 < Pplat < 25$ cmH_2O
Brain injury	Passive or active	$6 < Pplat < 25$ cmH_2O
Chronic hyperCO_2	Passive or active	$6 < Pplat < 25$ cmH_2O
None or ALI/ARDS	Active	$12 < RR < 30$ b/min
Brain injury	Active	$15 < RR < 35$ b/min
Chronic hyperCO_2	Active	$15 < RR < 35$ b/min

Wysocki. Intensive Care Med 2010

Benefits of IntelliVent-ASV
Safety and efficacy: passive ICU patients

Randomized cross-over study:

- 50 passive ICU patients: 19 normal lungs and 31 ARDS patients
- Two periods of 2 hours
- Control period: ASV

Results:

- No safety event, no switch to other mode

Arnal. Intensive Care Med 2012

Benefits of IntelliVent-ASV

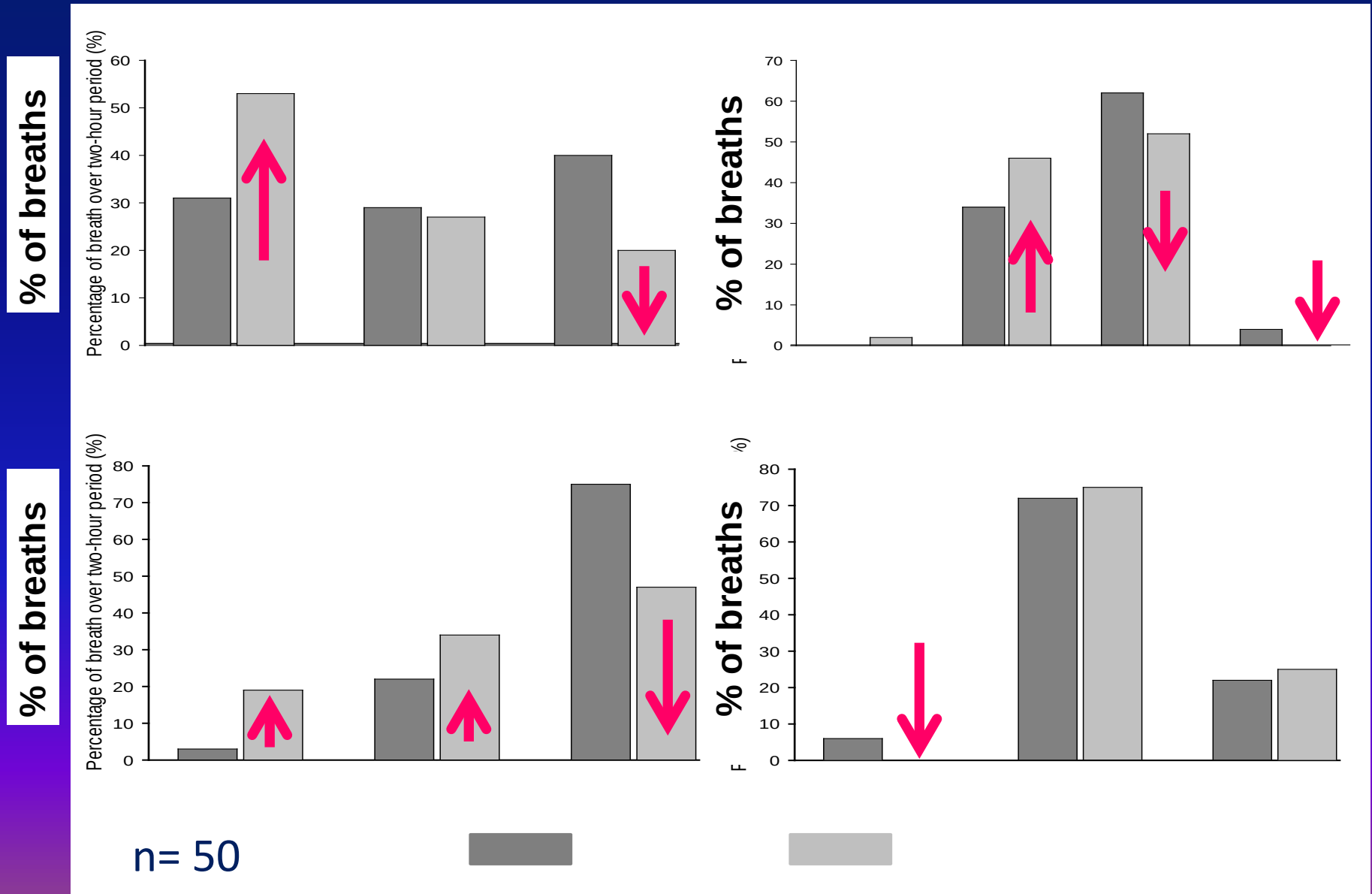
Safety and efficacy: passive ICU patients

n= 50

Parameter	ASV	IntelliVent-ASV®	*p*
MV (L/min)	7.6 (6.5–9.5)	6.8 (6.0–8.0)	<0.001
V_T/PBW (mL/kg)	8.3 (7.8–9.0)	8.1 (7.7–8.6)	0.003
RR (breath/min)	15 (14–17)	14 (13–17)	0.004
P_{INSP} (cmH_2O)	28 (24–33)	25 (22–29)	<0.001
P_{PLAT} (cmH_2O)	24 (20–29)	20 (19–25)	0.005
PEEP (cmH_2O)	10 (6–14)	8 (5–10)	0.011
FiO_2 (%)	40 (30–50)	30 (30–39)	<0.001
C_{STAT} (mL/cmH_2O)	37 (31–48)	37 (29–44)	0.935
R_{INS} (cmH_2O s/L)	16 (14–18)	17 (14–19)	0.699
RC_{EXP} (s)	0.7 (0.6–0.8)	0.7 (0.6–0.8)	0.326
pH	7.3 (7.3–7.4)	7.3 (7.2–7.4)	0.104
PaO_2 (mmHg)	92 (81–124)	84 (75–104)	0.052
PaO_2/FiO_2 (mmHg)	240 (163–318)	259 (197–323)	0.117
$PaCO_2$ (mmHg)	37 (34–42)	37 (33–49)	0.026
SaO_2 (%)	97 (95–98)	96 (93–98)	0.028
Dead space (mL)	144 (99–224)	134 (85–209)	0.009

Arnal. Intensive Care Med 2012

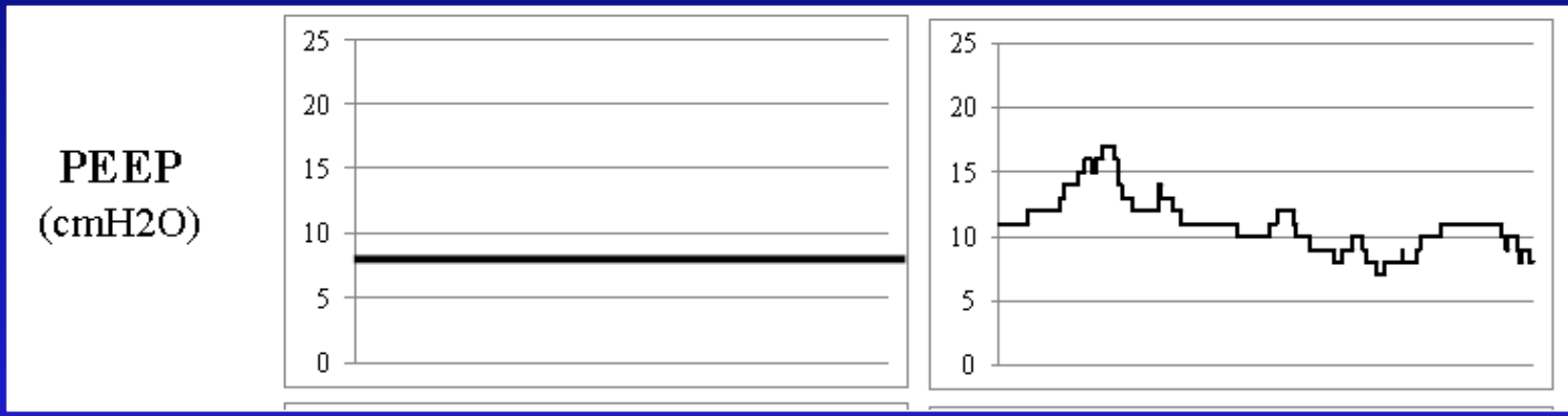
Benefits of IntelliVent-ASV
Safety and efficacy: passive ICU patients



Benefits of IntelliVent-ASV
Safety and efficacy: spont ICU patients

Randomized cross-over study:

- 14 ICU patients in spontaneous ventilation
- Two periods of 24 hours
- Control period PS

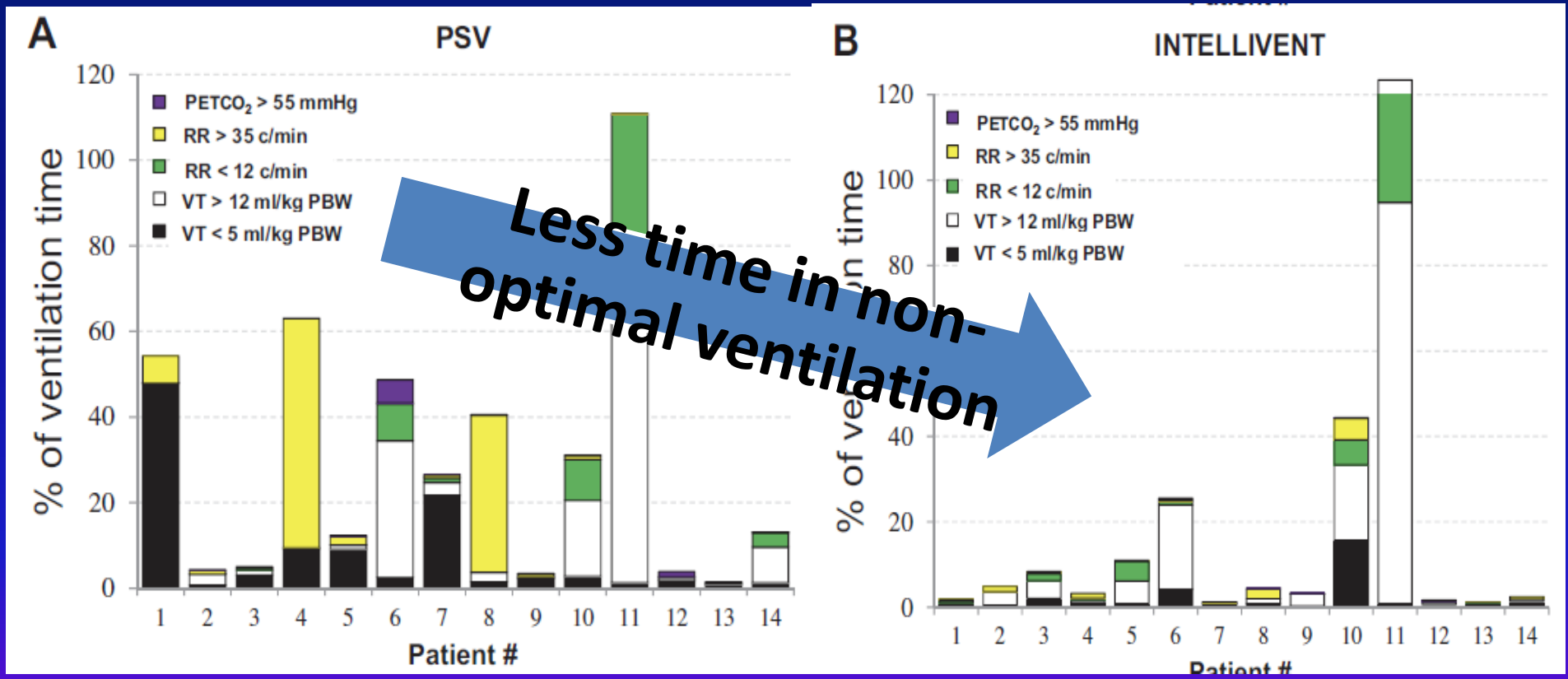


Results:

- No safety event, no switch to other mode

Clavieras. Anesthesiology 2013

Benefits of IntelliVent-ASV
Safety and efficacy: spont ICU patients



Clavieras. Anesthesiology 2013

Benefits of IntelliVent-ASV
Safety and efficacy: post cardiac surgery

Randomized controlled trial:

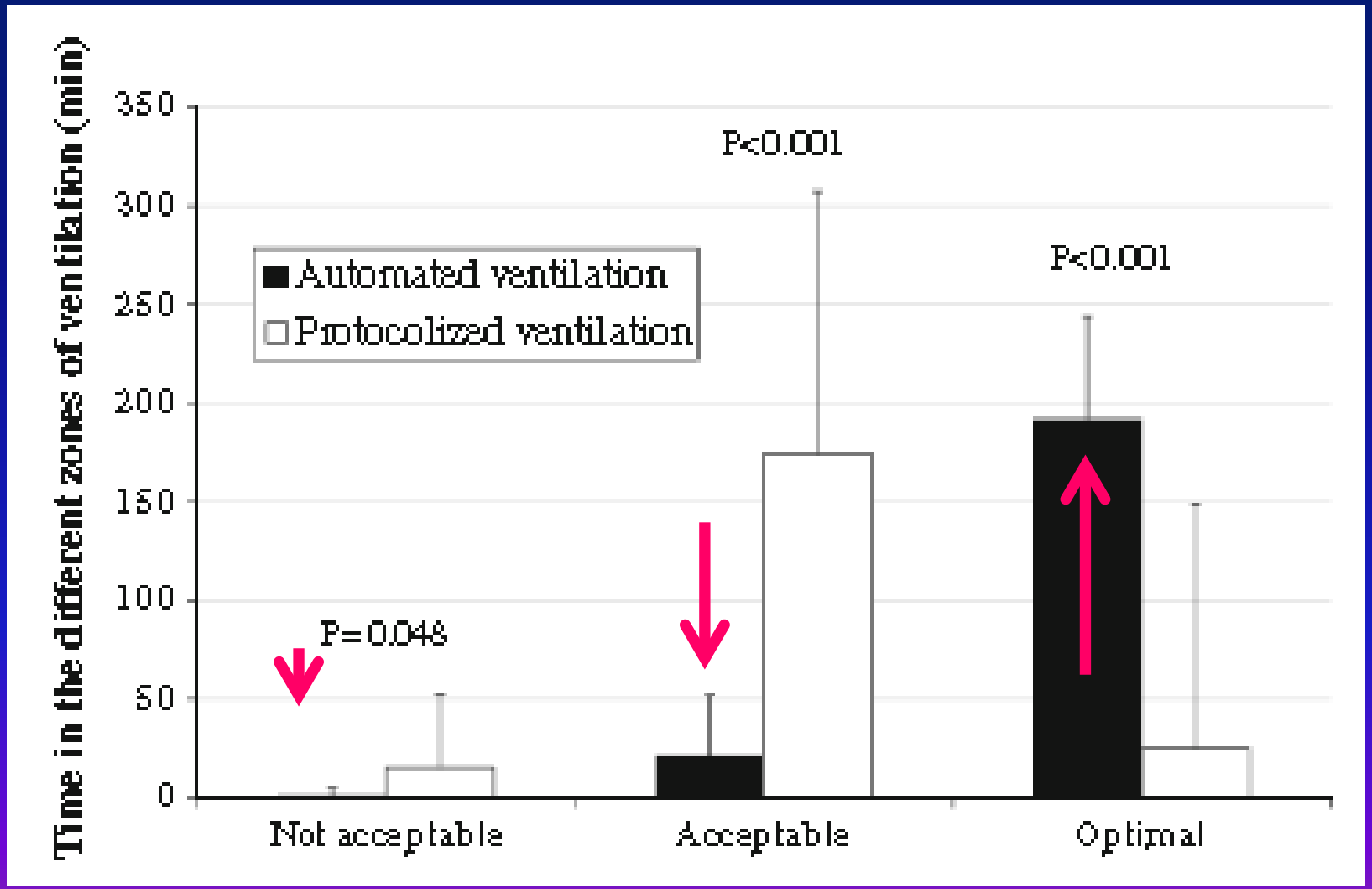
- 60 patients after elective non complicated cardiac surgery
- Over 4 hours
- Control group: protocolized SIMV + PS

Results:

- No safety event, no switch to other mode

Lellouche. Intensive Care Med 2013

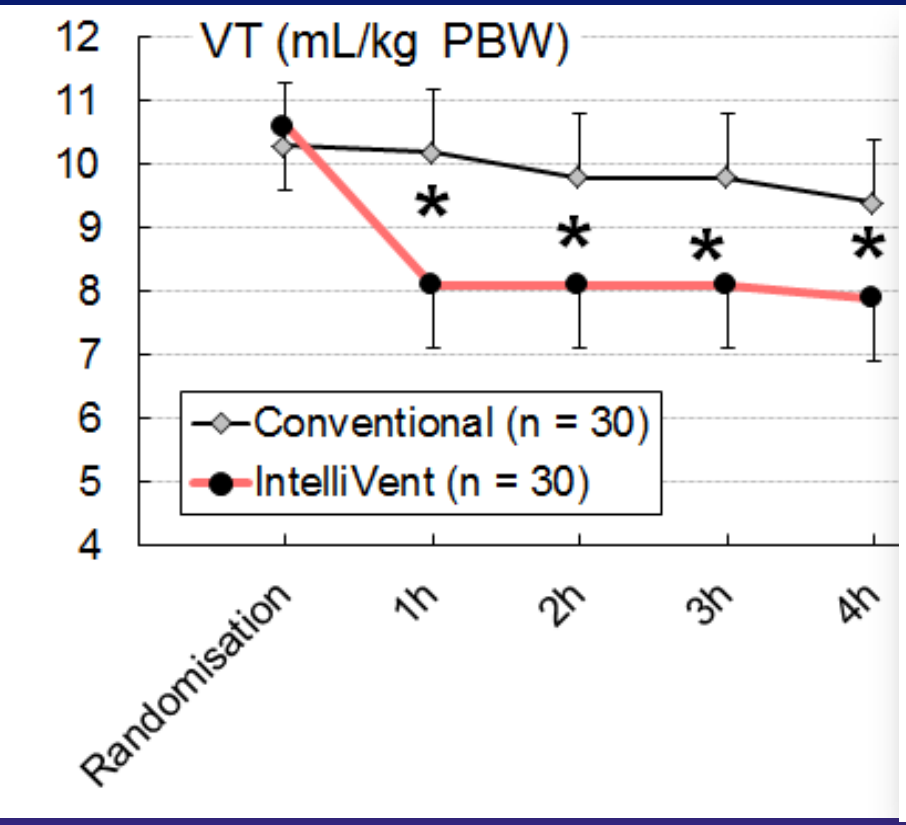
Benefits of IntelliVent-ASV
Safety and efficacy: post cardiac surgery

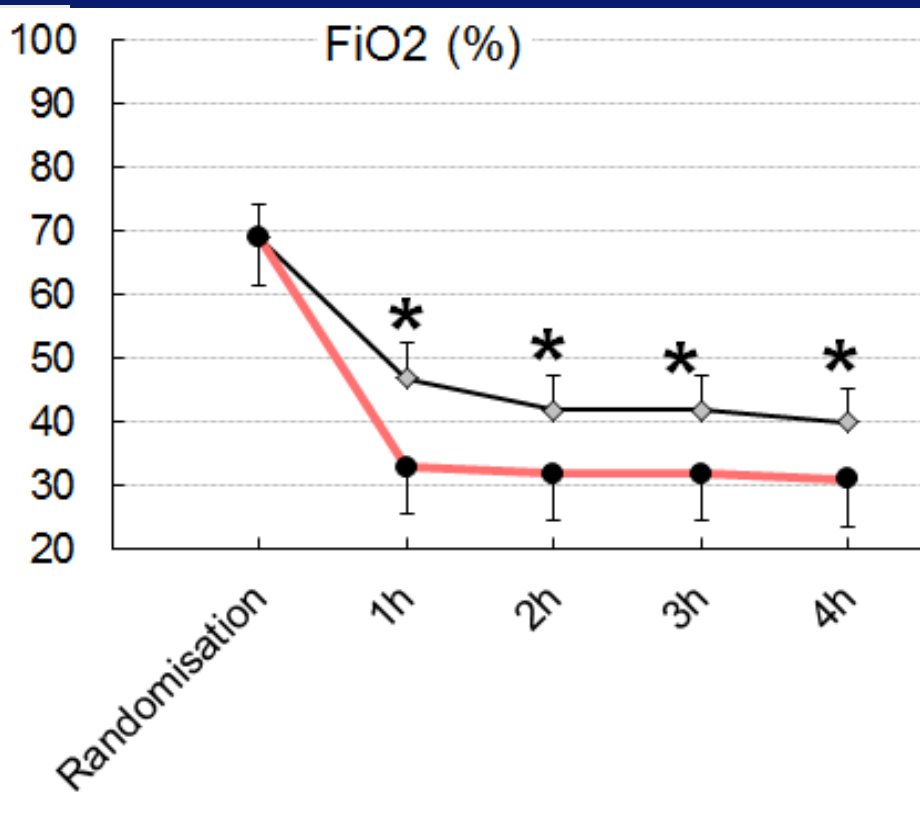


n= 60

Lellouche. Intensive care Med 2013

Benefits of IntelliVent-ASV
Safety and efficacy: post cardiac surgery





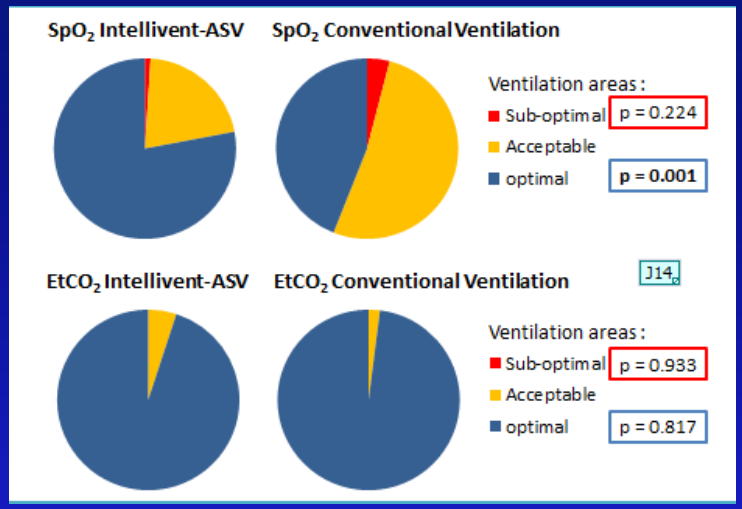
Note, conventional patients set at 10mk/kg/PBW

n= 60

Lellouche. Intensive care Med 2013

Benefits of IntelliVent-ASV
Safety and efficacy studies

- ICU patients: RCT 80 patients



Bialais. Critical Care 2013 [abstract]

- Pediatric patients: sequential study

n= 10	PSV (1 hr)	ASV (1hr)	IntelliVent (1hr)	PSV (1hr)
Time in normal breathing range(%)	82 ± 31	91 ± 10	94± 2	
number of ventilator setting modifications (n)	0 (0-0)	0 (0-0)	77 (57-120)	0 (0-0)

Jouvet . Critical Care 2012

Benefits of IntelliVent-ASV
Feasibility study in ICU

Prospective observational comparative study:

- 100 unselected ICU patients with expected duration MV > 24 hours
- Intubation to weaning or death , MV duration 3 (2-7) days

Results:

- No safety event, no switch to other mode

Arnal. Critical Care 2013

Benefits of IntelliVent-ASV
Feasibility study in ICU

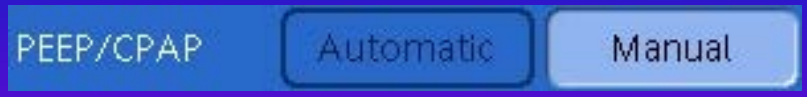
100 patients
392 days
of ventilation
analyzed

2 patients for one day

Large CO_2 gradient

7 patients for one day

Poor SpO_2 signal

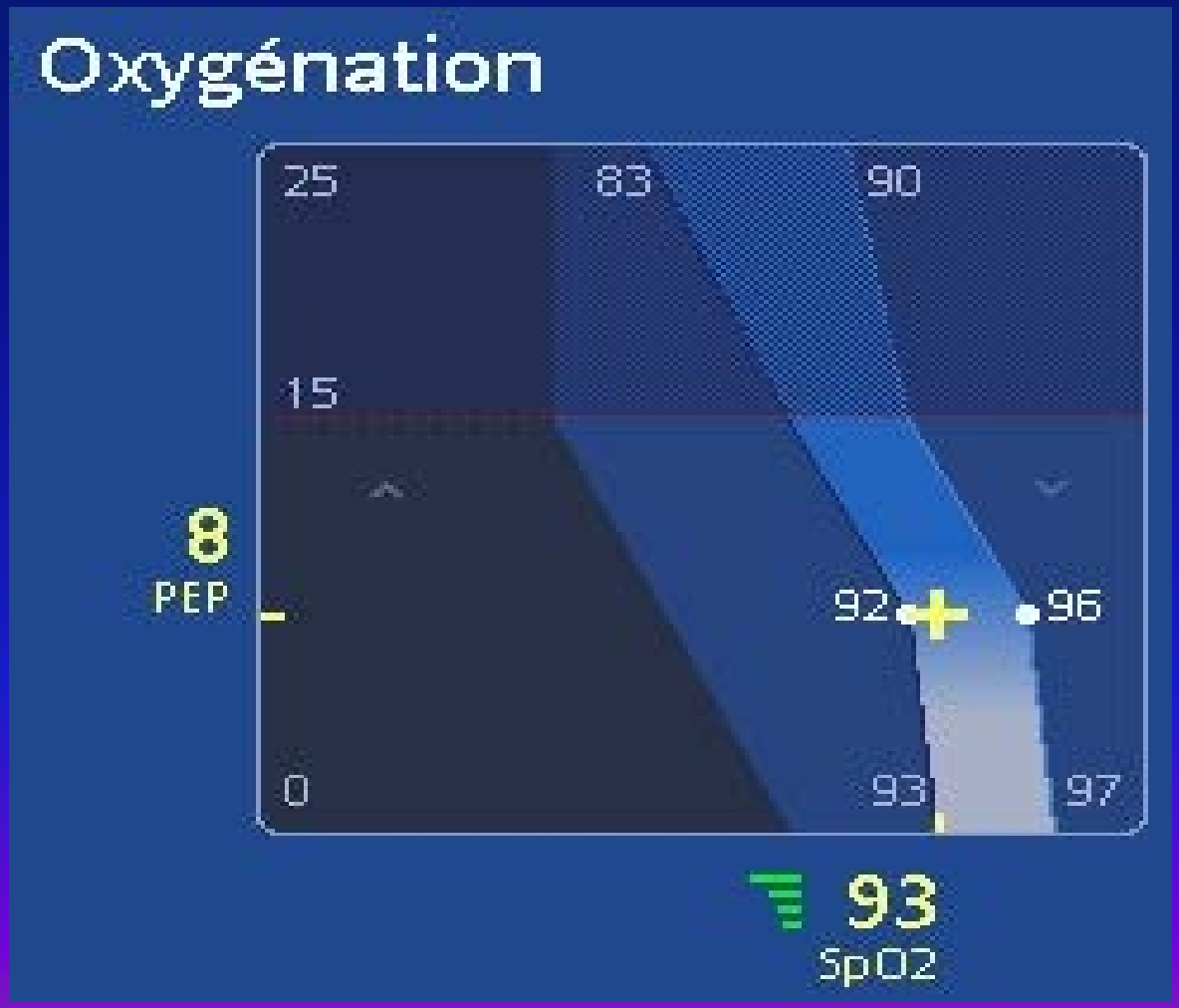


3 patients

Increased PEEPi, PNO, P_{ESO}

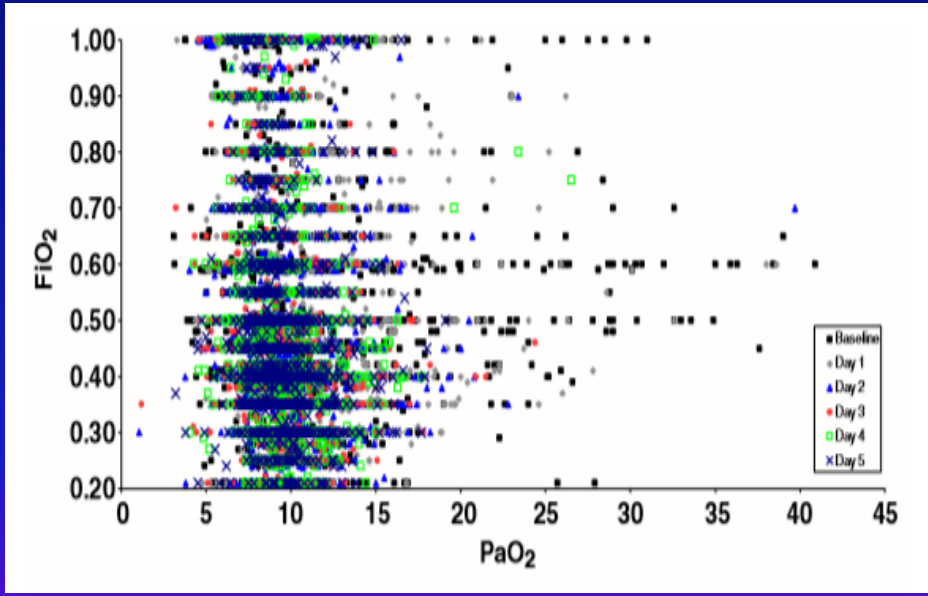
Arnal. Critical Care 2013

Benefits of IntelliVent-ASV
Prevent hypoxemia



Benefits of IntelliVent-ASV
Prevent hyperoxia

1 770 patients with sepsis



Dahl. Acta Anaesth Scand 2015

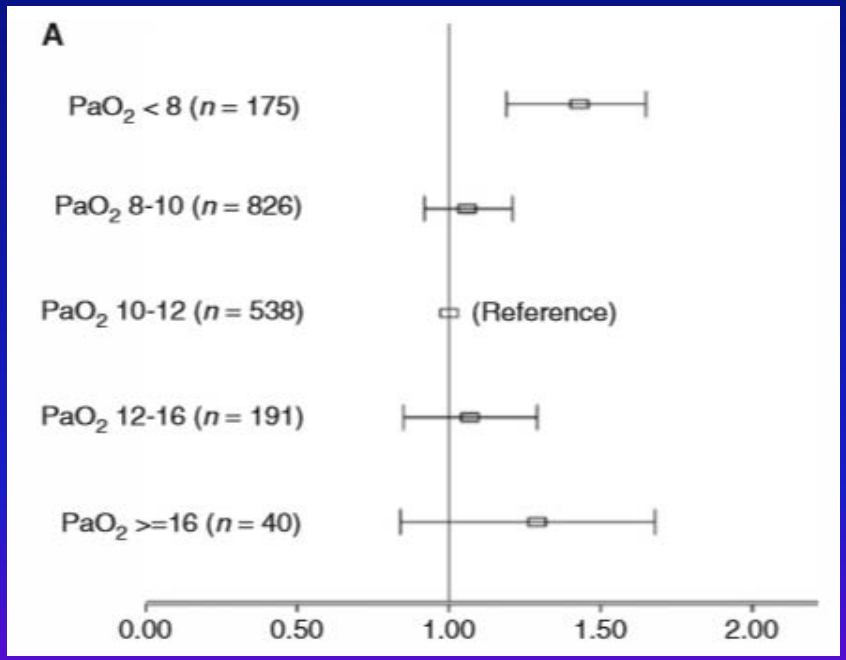
5 498 patients

PaO_2 category (kPa)	*n* (%)	PaO_2 (kPa, mean ± SD)	FiO_2	PEEP (cmH_2O)
<8	4,544 (3.6)	7.3 ± 0.7	0.5 (0.4–0.61)	10 (7–12)
8.01–10	21,335 (16.8)	9.2 ± 0.6	0.45 (0.4–0.51)	9 (5–12)
10.01–13	45,545 (35.9)	11.5 ± 0.8	0.4 (0.4– 0.5)	8 (5–10)
13.01–16	27,132 (21.4)	14.4 ± 0.9	0.4 (0.4–0.42)	5 (5–10)
>16.01	28,222 (22.3)	20.7 ± 6.0	0.4 (0.4–0.45)	5 (5–10)

De Graff. Intensive Care Med 2011

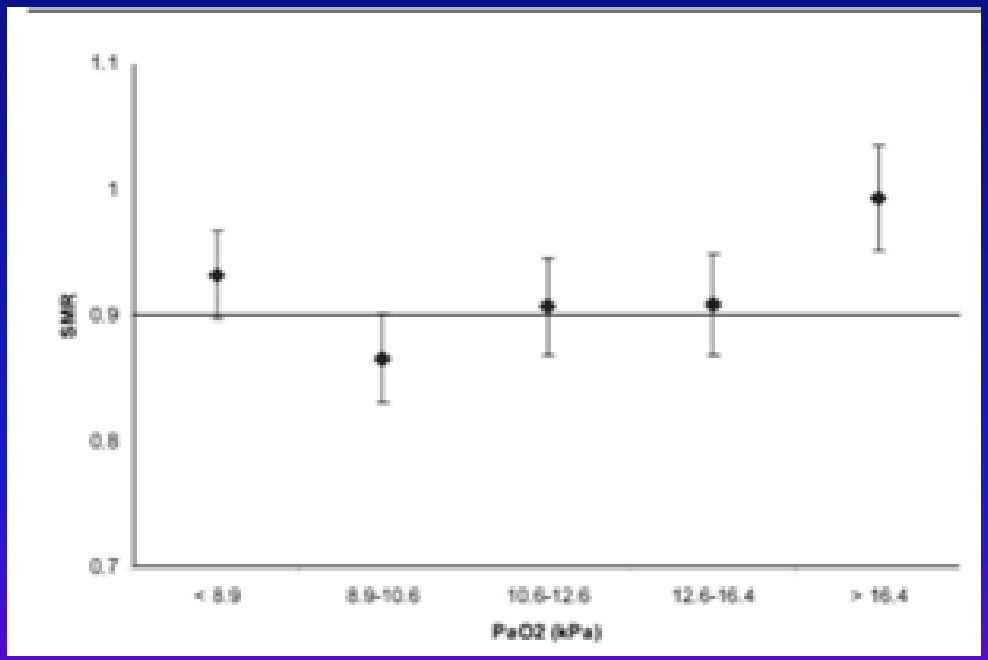
Benefits of IntelliVent-ASV
Prevent hyperoxia

1 770 patients with sepsis



Dahl. Acta Anaesth Scand 2015

3 322 patients



De Jonge. Crit Care 2008

Benefits of IntelliVent-ASV
Prevent hyperoxia

	1 Normal lung	2 ARDS	3 COPD	4 Others	p (ANOVA)
Number of patients	45	16	19	20	
Number of days	139	90	79	84	
PaO_2/FiO_2 (mm Hg)	326 (267-380)	206 (172-252)	260 (206-328)	241 (189-304)	< 0.001
PaO_2 (mm Hg)	100 (85-117)	76 (69-84)	86 (74-105)	82 (73-95)	< 0.001
pH	7.36 (7.30-7.41)	7.35 (7.23-7.42)	7.30 (7.25-7.35)	7.33 (7.26-7.41)	< 0.001
$PaCO_2$ (mm Hg)	35 (31-40)	41 (35-49)	45 (37-53)	39 (34-46)	< 0.001

Prospective observational comparative study:
100 unselected ICU patients

Arnal. Critical Care 2013

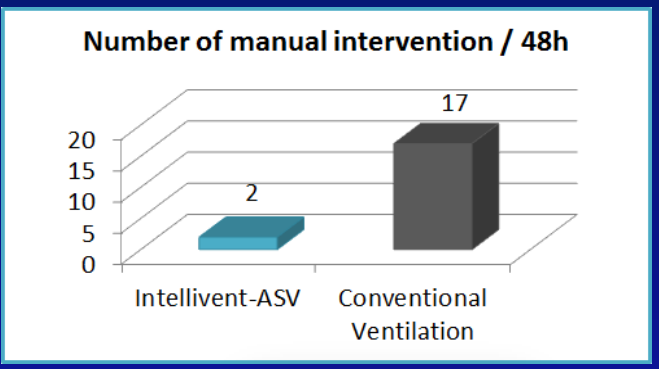
Benefits of IntelliVent-ASV
Application of recommendations

	ARDS mild Passive	ARDS moderate Passive	ARDS severe Passive
RC_{EXP} (s)	0.45 (0.43-0.55)	0.47 (0.44-0.57)	0.40 (0.24-0.43)
C_{STAT} (L/cm H_2O)	42 (35-51)	43 (38-48)	19 (14-35)
V_T/PBW (mL/kg)	6.5 (5.9-8.0)	6.9 (6.3-7.5)	5.4 (5.0-5.9)
Driving pressure (cmH_20)	10 (8-11)	9 (7 – 10)	10 (8 -12)
P_{PLAT} (cm H_2O)	20 (18-24)	20 (17-23)	24 (20-26)

n= 44

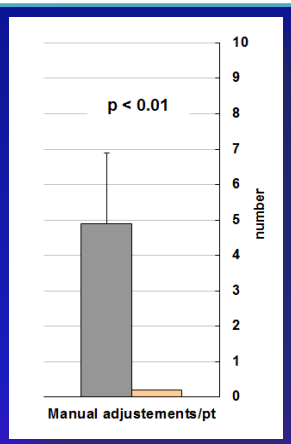
Personal data 2015

Benefits of IntelliVent-ASV
Reduce workload



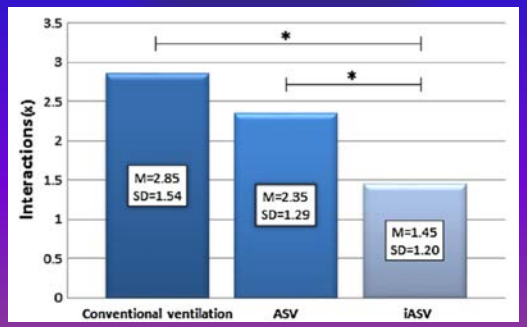
80 ICU patients

Bialais. Intensive Care Medecine 2013 [abstract]



60 post cardiac surgery patients

Lellouche. Intensive care Med 2013



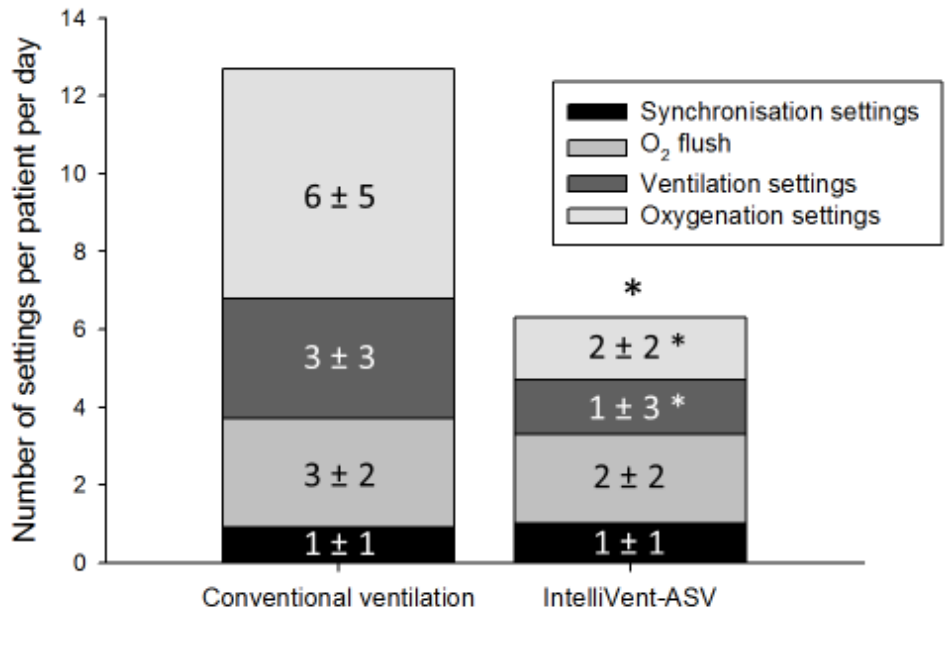
128 post cardiac surgery patients

Beijers. Intensive care Med 2014

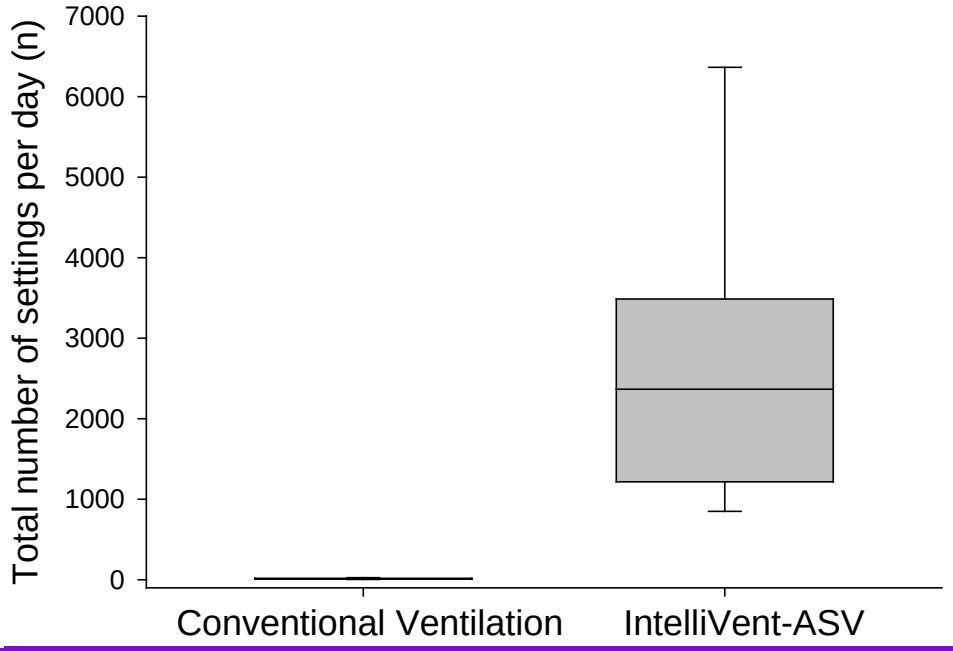
Benefits of IntelliVent-ASV
Reduce workload

60 ICU patients ventilated for more than 48 hours
IntelliVent-ASV versus VAC+PS with protocolized weaning

Manual settings

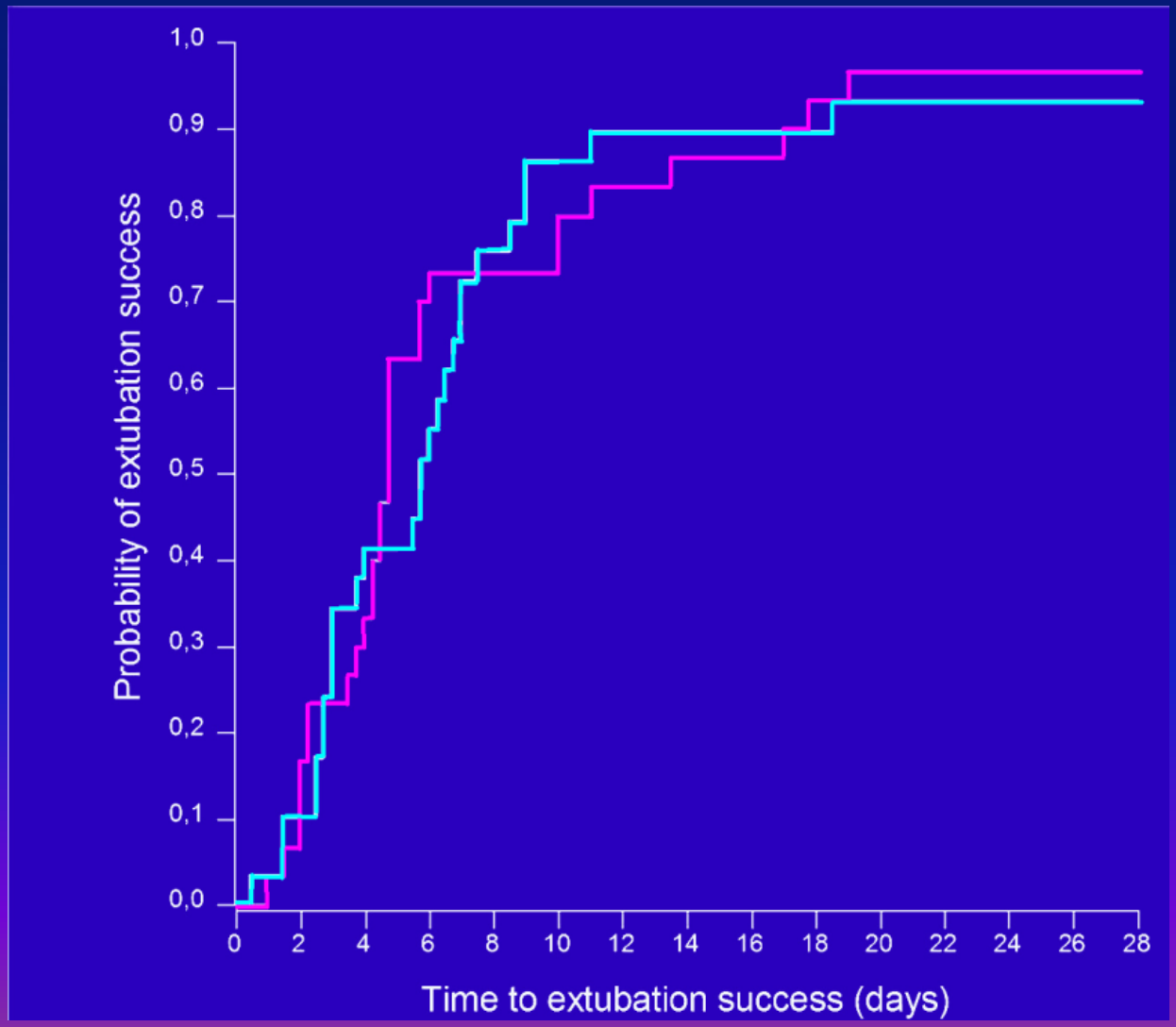


Automated settings



Arnal [submitted]

Benefits of IntelliVent-ASV Outcomes

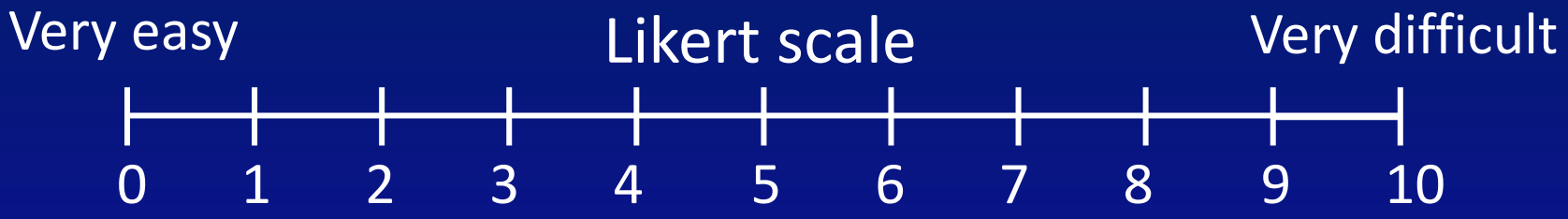


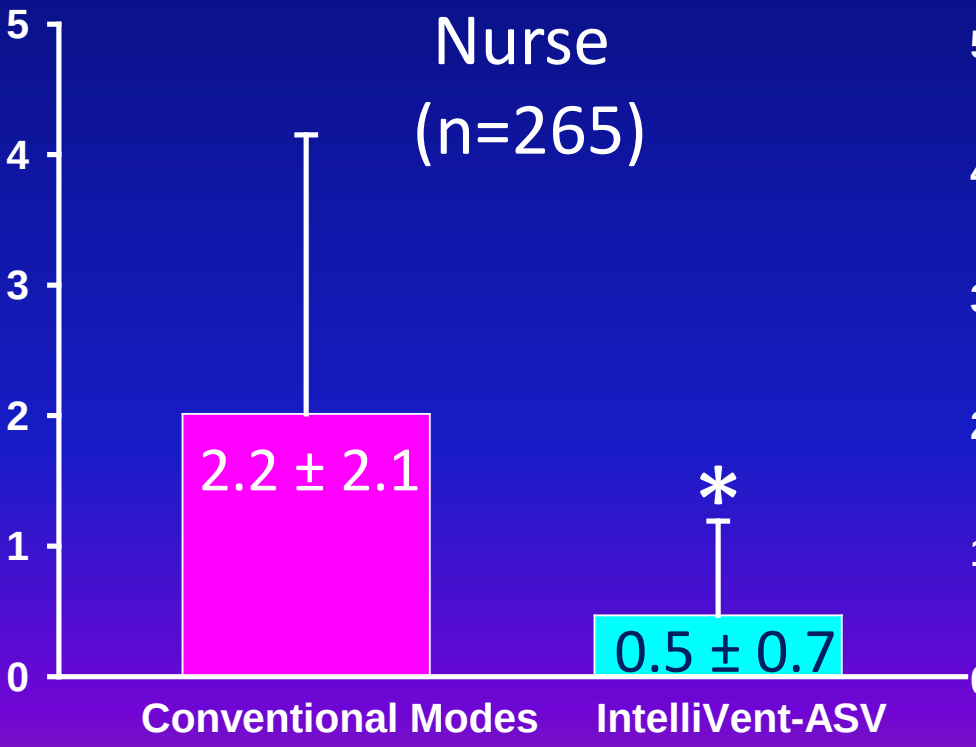
IntelliVent-ASV

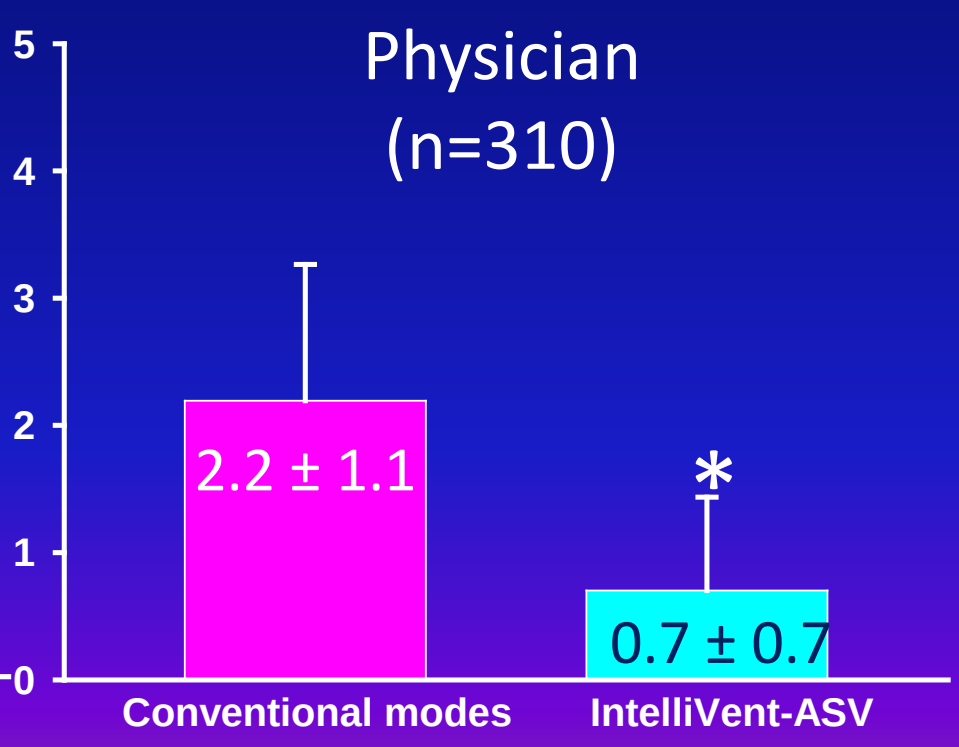
VAC and PS

Arnal [submitted]

Benefits of IntelliVent-ASV
Easiness of use





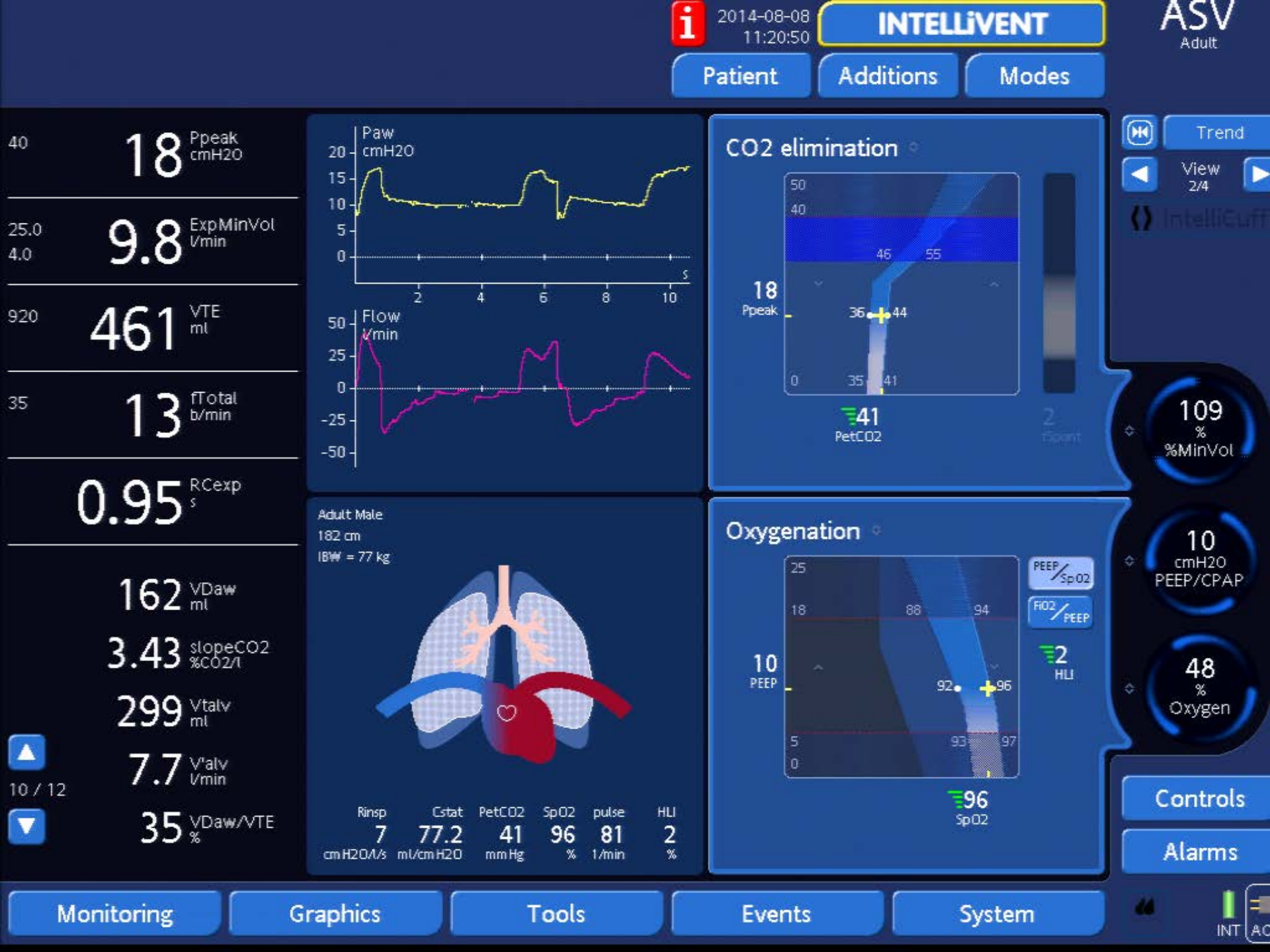


n= 60 * $p < 0.001$

Arnal [submitted]

IntelliVent-ASV additional benefits

- Increase consistency of care
- Timely adjustment when mobilization
- Less sedation required
- … Improved organization


2014-08-08
11:20:50
INTELLiVENT
ASV
Adult
Patient
Additions
Modes
40
18
Ppeak
cmH2O
25.0
4.0
9.8
ExpMinVol
l/min
920
461
VTE
ml
35
13
fTotal
b/min
0.95
RCexp
s
162
VDaw
ml
3.43
slopeCO2
%CO2/l
299
Vtalv
ml
7.7
V'alv
l/min
35
VDaw/VTE
%
10 / 12
Paw
cmH2O
Flow
l/min
s
CO2 elimination
18
Ppeak
41
PetCO2
2
Point
Trend
View
2/4
IntelliCuff
109
%
%MinVol
10
cmH2O
PEEP/CPAP
48
%
Oxygen
Adult Male
182 cm
IBW = 77 kg
Oxygenation
10
PEEP
PEEP/SpO2
FiO2/PEEP
2
HLI
96
SpO2
Rinsp
7
cmH2O/l/s
Cstat
77.2
ml/cmH2O
PetCO2
41
mmHg
SpO2
96
%
pulse
81
1/min
HLI
2
%
Controls
Alarms
Monitoring
Graphics
Tools
Events
System
INT
AC

IntelliVent-ASV risks
Sensor accuracy

SpO_2

n = 100 measurements

Compare SpO_2 to SaO_2

Bias = 0.2 %

Limits of agreement: -0.4 to 0.8 %

Precision= 2.4 ± 0.2 %

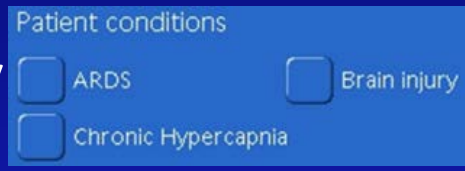
E_TCO_2

	n	$PaCO_2 – E_TCO_2$ (mm Hg)
All patients	100	4 (0 -9)
Passive patients	47	1 (-1 -5)
Active patients	53	7 (1 -13)
Normal lungs all	46	3 (0 -10)
Normal lungs passive	20	1 (-2 -6)
Normal lungs active	26	7 (0 -11)
COPD all	21	7 (0 -14)
COPD passive	9	0 (-5 -2)
COPD active	12	9 (7 -16)
ARDS all	34	3 (-1 -6)
ARDS passive	17	2 (-1 -5)
ARDS active	17	5 (2 -8)

IntelliVent-ASV risks
Safety features

- Maximum pressure limitation

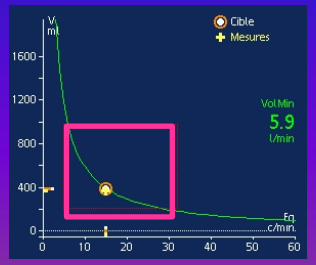
- PEEP manual in hypercapnic and brain injury



- Ranges of PEEP

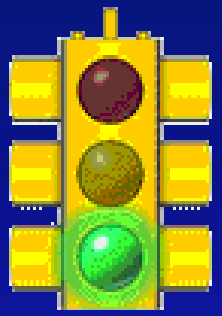
- Automatic PEEP limitation according to hemodynamic

- ASV automatic limits for V_T and RR



IntelliVent-ASV risks
Not appropriate for some patients?

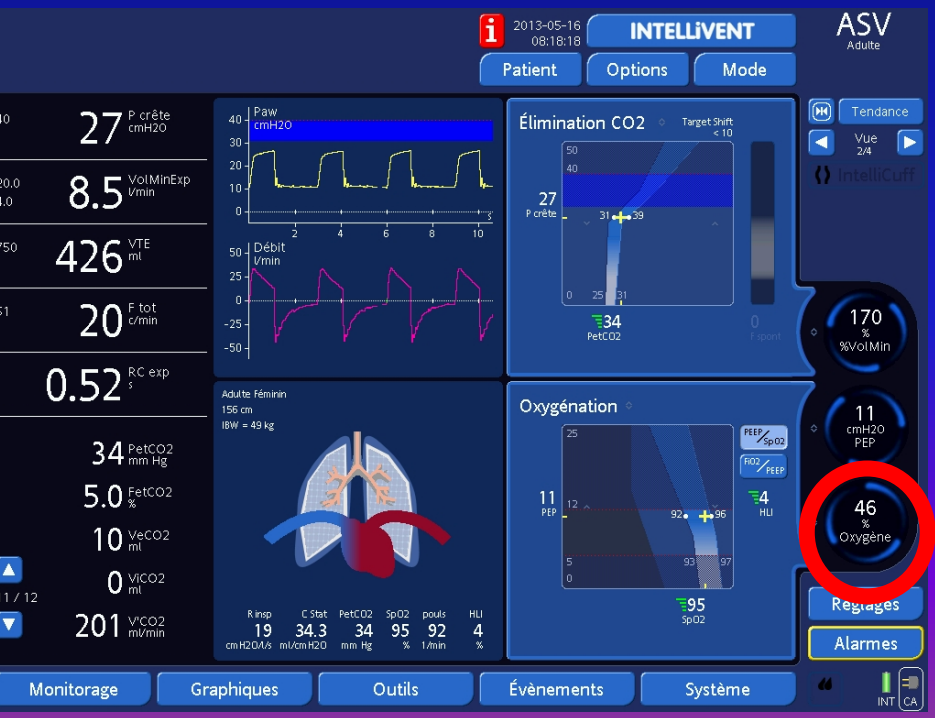
- Absolute : ventilation with leaks
  - NIV
  - Bronchopleural fistula

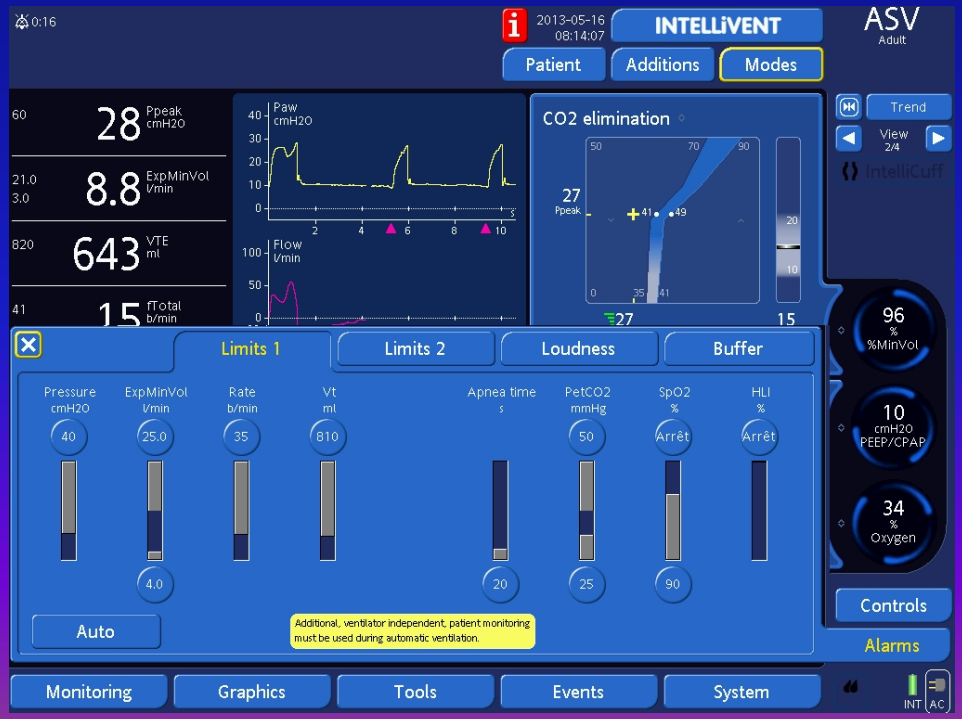


- Particular situations:
  - Oxygenation controller and dyshemoglobin: CO poisoning, methemoglobin, monozygotic Sickle cell disease.
  - PEEP controller in case of hemodynamic instability

IntelliVent-ASV risks
Loss of situation awareness

- Monitoring is slightly different
- Alarms are important
- Require a dedicated training





Why do we make mistakes?

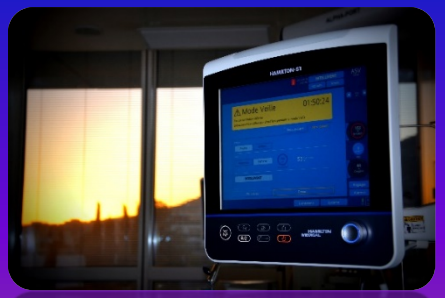
- I was tired
- I forgot
- I was distracted
- My attention lapsed
- I was stressed
- I was short of time
- My staff was new
- My staff was inexperienced
- The equipment was difficult to use
- I made an error of judgment

The future

- Will we have more staff?
- Will we have more experienced staff?
- Will our patient be less complex?
- Will we have more time?

Conclusion

- IntelliVent-ASV full closed loop ventilation mode
- Clinician set and adjust targets and limits
- Uses well known physiological measurements
- No safety event reported out of ≈ 30 000 patients
- Greatest benefits: safety, lung protection, and organization
- Greatest risk: insufficient user training
- One way to prepare our future challenges



Thank you… ☺